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CONCERN OVER THE FINAL DISPOSITION OF THE BASIN F LIQUID HAS PROMPTED THIS EVAPORATION EXPERIMENT INITIATED IN JUNE, 1980. THE PURPOSE OF THE EVAPORATION EXPERIMENT WAS (1) TO DETERMINE THE EVAPORATION RATE OF BASIN F LIQUID, (2) IDENTIFY ANY CHANGES IN THE EVAPORATION RATE AT VARIOUS STAGES OF DRYNESS, (3) IDENTIFY ANY CHANGES IN THE PHYSICAL AND CHEMICAL PROPERTIES OF THE BASIN F LIQUID AT THE VARIOUS STAGES OF DRYNESS, (4) DETERMINE THE APPROXIMATE WEIGHT OF SOLIDS TO BE EXPECTED AT THE EQUILIBRIUM CONCENTRATION OR AT DRYNESS, AND (5) DETERMINE IF THE BASIN WILL EVAPORATE TO AN EQUILIBRIUM CONCENTRATION OR COMPLETELY TO DRYNESS.

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INTERIM REPORT:

BASIN F EVAPORATION STUDY

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INTRODUCTION

Concern over the final disposition of the Basin "F" liquid has prompted the initiation of several studies into the possible methods of treatment and/or stabilization of the Basin "F" liquid. One such study is an evaporation experiment initiated in June 1980 by personnel of the Treatment Technology Branch. The purpose of the evaporation experiment was to (1) determine the evaporation rate of the Basin "F" liquid, (2) identify any changes in the evaporation rate at various stages of dryness, (3) identify any changes in the physical and chemical properties of the Basin "F" liquid at various stages of dryness, (4) determine the approximate weight of solids to be expected at the equilibrium concentration or at dryness, and (5) determine if the Basin will evaporate to an equilibrium concentration or completely to dryness.

DESCRIPTION

The evaporation experiment was divided into two concurrent studies, Part A and Part B. The first of these experiments, Part A, was carried out to determine the monthly evaporation rate of the Basin "F" liquid. The monthly evaporation rate was found by filling three stainless steel cylinders (40" deep X 35" dia) with liquid. Two of the containers were filled with Basin "F" fluid and the third container, a control, was filled with tap water. The cylinders containing Basin "F" liquid were allowed to evaporate to approximately a 60% reduction in volume at which point one of the cylinders was emptied and refilled with fresh Basin "F" liquid, this cylinder was then routinely emptied and refilled monthly. The second cylinder containing Basin "F" liquid was allowed to continue evaporating to determine if the Basin "F" liquid will evaporate to an equilibrium concentration or completely

to dryness. The control cylinder containing tap water was refilled whenever the cylinder approached dryness. Measurements of the evaporative losses were made twice weekly. Liquid samples were taken at various stages of dryness for laboratory analysis of physical and chemical properties.

The second of the experiments, Part B, was carried out to determine the effects of concentration on the evaporation rate of the Basin "F" liquid. Part B was executed using two shallow (10" deep X 47½" dia) plastic pans. One of the pans was filled with Basin "F" liquid and the second pan, a control, was filled with tap water. When the evaporative loss from the pans was between 2in and 3in the pans were refilled with fresh liquid.

DATA

Both of the experiments mentioned above were started on 26 Jun 80, and are still being conducted. All data are for the time period 26 Jun thru 31 Dec 80.

CONCLUSIONS AND RECOMMENDATIONS

The evaporation rate of the Basin "F" liquid is significantly smaller, 37% less, than the evaporation rate of water over the same time period in identical containers. The net evaporation (evaporation - precipitation) for water is 40.33 in and for Basin "F" liquid only 25.5 in of evaporation occured. This difference can be seen by comparing Graph 1, "Evaporation of Basin "F" Liquid, Part A", to Graph 2, "Evaporation of Water, Part A". The difference in evaporation rates is due to the high salt content, 35.5% of the Basin "F" liquid and because of the presence of high boiling organic liquids both of which reduce the vapor pressure of the Basin "F" liquid.

The evaporation rate of the Basin "F" liquid drops continually from the start of the experiment. However, there is a significant decrease in the rate of evaporation starting at day 117, (see Graph 1). The two most

probable causes for the decreased evaporation rate are (1) temperature effects; or (2) a change in the physical and/or chemical properties of the Basin "F" liquid causing a decrease in the vapor pressure. The evaporation rate of the water in the control pan also decreases during the same period of time, (see Graph 2). However, the evaporation rate of the Basin "F" liquid slows more than does the rate of water. Because of the differences in slowing the actual cause of the depressed evaporation rate is probably a combination of temperature effects and a change in the physical and/or chemical properties of the liquid.

The Basin "F" liquids physical and chemical properties have changed dramatically during the course of the evaporation experiment, (see Table 1). The density of the liquid has gone from a starting value of 1.190 gm/ml to a high or 1.295 gm/ml at 72% reduction in volume. The sample for the 72% reduction in volume was taken from the pan in Part B of the evaporation experiment while all of the others were taken from the pan in Part A. This may account for the large deviation in the densities between the 62% value and the 72% value, (see Graph 5).

The concentration of total solids (suspended solids and dissolved solids) steadily increases as the volume of the liquid decreases, (see Graph 6). The amount of suspended solids in the liquid remain quite low and fairly constant, while the weight of the dissolved solids increases.

Using a total solids value of 35.48 gm/ml at the beginning of the evaporation experiment and a total Basin "F" liquid volume of 82,792,600 gal. (value from the as built drawings and a liquid elevation of 5193.94 ft.) the total amount of solids remaining if the Basin evaporated to dryness would be 245 million pounds.

Some predictions can be made from the data obtained thus far in the evaporation experiment. The net evaporation of the Basin "F" liquid in Part A of the evaporation experiment is 25.5 in. According to evaporation maps developed by the National Weather Service, Denver Colorado has a mean pan coefficient of 0.70. Multiplying the pan coefficient by the height of evaporative loss will yeild the expected hieght of evaporation from Basin "F" during the period of 1 Jul 80 to 29 Dec 80. The height of evaporation from Basin "F" would be:

$$(25.5 \text{ in.})\ (0.70) = 17.85 \text{ in.}$$

Using a surveyed height on 26 Jun 80 of 5193.94 ft and a liquid elevation of 5192.43 ft. on 5 Jan 81, the actual loss from the Basin is:

$$(5193.94 \text{ ft}) - (5192.43 \text{ ft.}) = 1.51 \text{ ft.}$$

$$(1.51 \text{ ft.})\ (12 \text{ in./ft.}) = 18.12 \text{ in.}$$

From this there is only a 1.5% error between the actual amount of evaporation and the predicted value from the pan data.

The net evaporation of the water in Part A of the evaporation experiment is 40.33 in. Again using a pan coefficient of 0.70 and multiplying the predicted amount of lake evaporation would be found. The expected amount for 1 Jul 80 to 29 Dec 80 would be:

$$(40.33 \text{ in.})\ (0.70) = 28.23 \text{ in.}$$

Appendix A: Climatalogical data for Denver, Colorado, gives a net evaporation of 45.77 in./year (50 percent exceeded, Table A1) and a net evaporation of 29.25 in. for July to December at 50 percent exceeded net evaporation. With an expected evaporation at 29.25 in. and an actual evaporation of 28.23 in. there is a difference of only 3.5 percent.

The height of evaporation from Basin "F" per year were calculated on the basis of 50 and 90 percent exceeded net evaporation. For the 50 percent exceeded net evaporation:

$$\frac{(17.85 \text{ in. Basin "F" liquid})}{(28.23 \text{ in. } H_2O)} \quad (45.77 \text{ in./year}) =$$

28.94 in. Basin "F" liquid/year

From the as built drawings of Basin "F" there is 7.43 ft. of liquid remaining as of 5 Jan 81. Using a 50 percent exceeded net evaporation of 28.94 in./year the time required to evaporate the entire Basin would be:

(7.43 ft.)/(28.94 in./year) = 3.08 years

Therefore, it would take until the beginning of 1984 for the Basin to evaporate. For 90 percent exceeded net evaporation:

(17.85 in.) (17.92 in./year)/(28.23 in.) =

11.33 in. Basin "F" liquid/year

The time required for total evaporation of 90 percent exceeded evaporation would be:

(7.43 ft.)/(11.33 in./year) = 7.87 years

7.87 years is the worst case time to evaporate the Basin and the actual time should be closer to the 3.08 years.

All of these calculation assume that the evaporation rate of the Basin "F" liquid does not change drastically as it dries and that the Basin will evaporate to dryness.

The large amount of solids that will be deposited in the Basin as the liquid level drops will act to slow the evaporation rate as the liquid will actually be between the crystals.

It is recommended at this time that enhanced evaporation techniques be studied and implemented in an attempt to reduce the volume of the Basin as soon as possible. It is also recommended that some form of solid removal technique be employed so the crystals can be removed as they form.

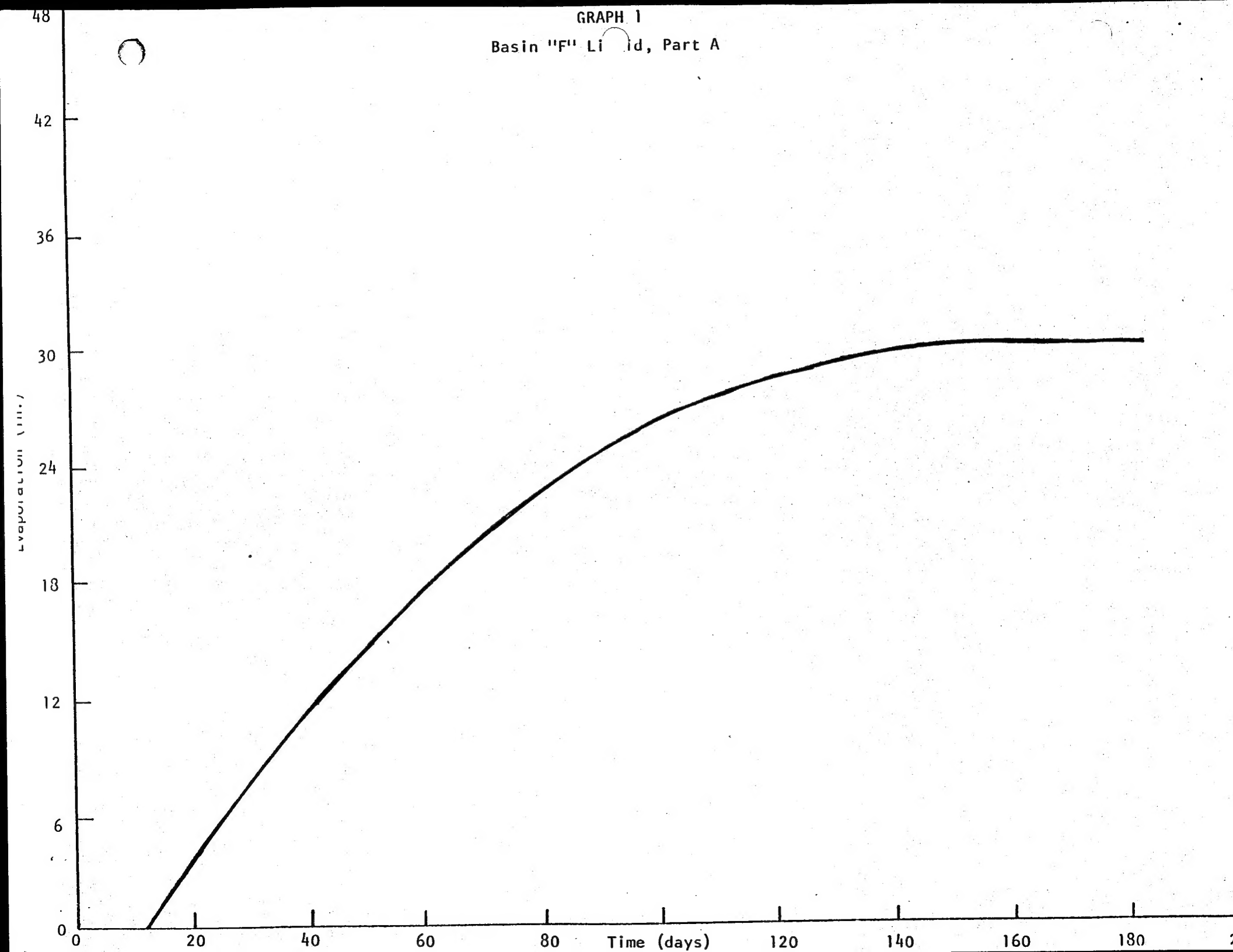
Table 1

Data Report Form Evapo. .ion Experiment

Date Sampled	% Volume Reduction	Density gm/ml	Na gm/l	Cl gm/l	Suspended solids gm/100 ml	Dissolved solids gm/100 ml	Total solids gm/100 ml	TOC mg/l		pH
6-26	0	1.190	100	143	0.34	35.14	35.48			6.40
7-18	10	1.230	140	160	0.39	42.78	43.17			6.31
7-29	21	1.230	135	165	0.36	47.10	47.46			6.23
8-8	30	1.230	127	165	0.44	50.43	50.87			6.15
8-29	40	1.235	127	195	0.54	49.60	50.14			5.93
9-30	54	1.240	87.5	195	0.37	59.82	60.99			6.07
10-22	62	1.250	86	180	0.33	65.56	65.83			6.05
10-22	72	1.295	54	101	0.29	*	*			6.06

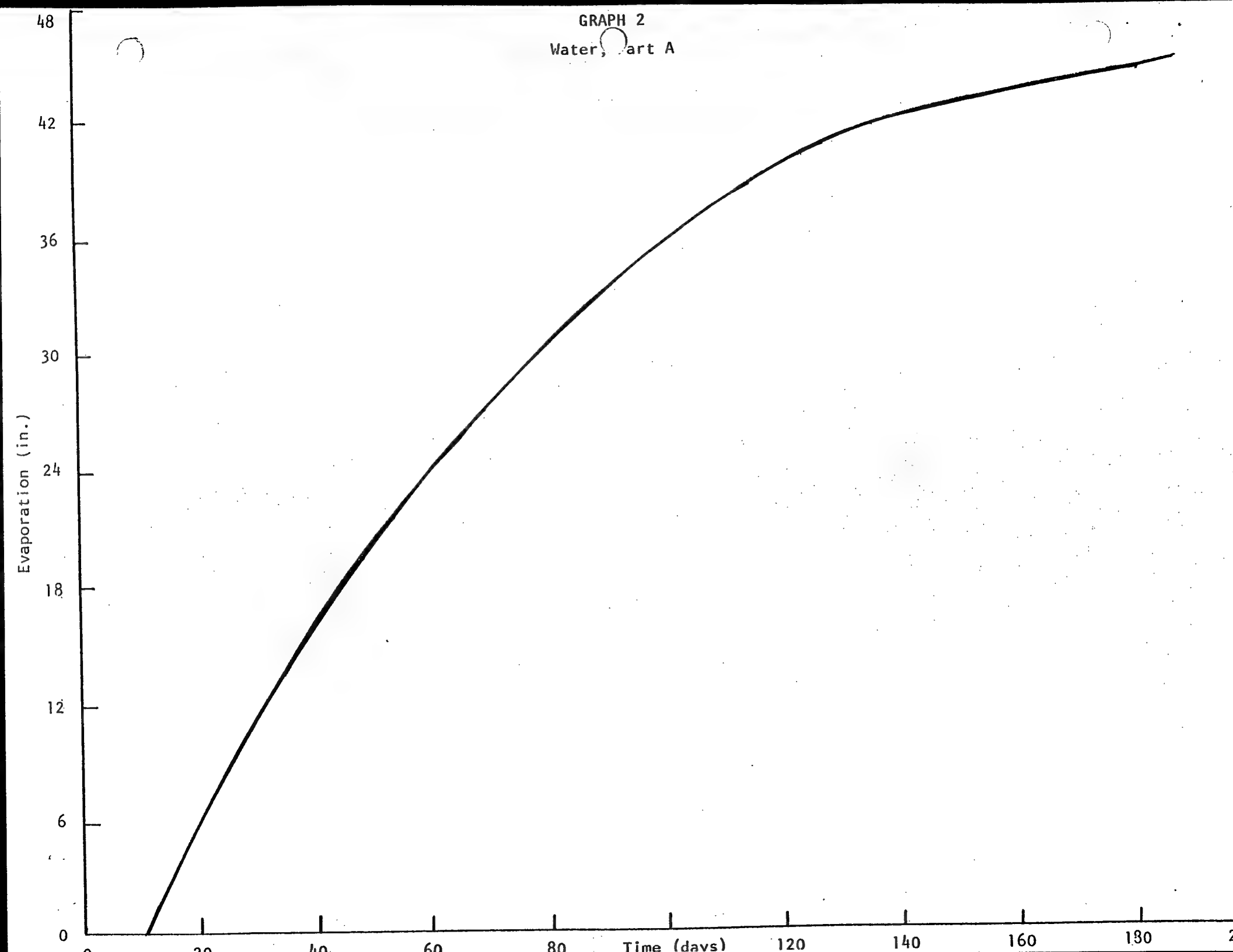
GRAPH 1

Basin "F" Li id, Part A



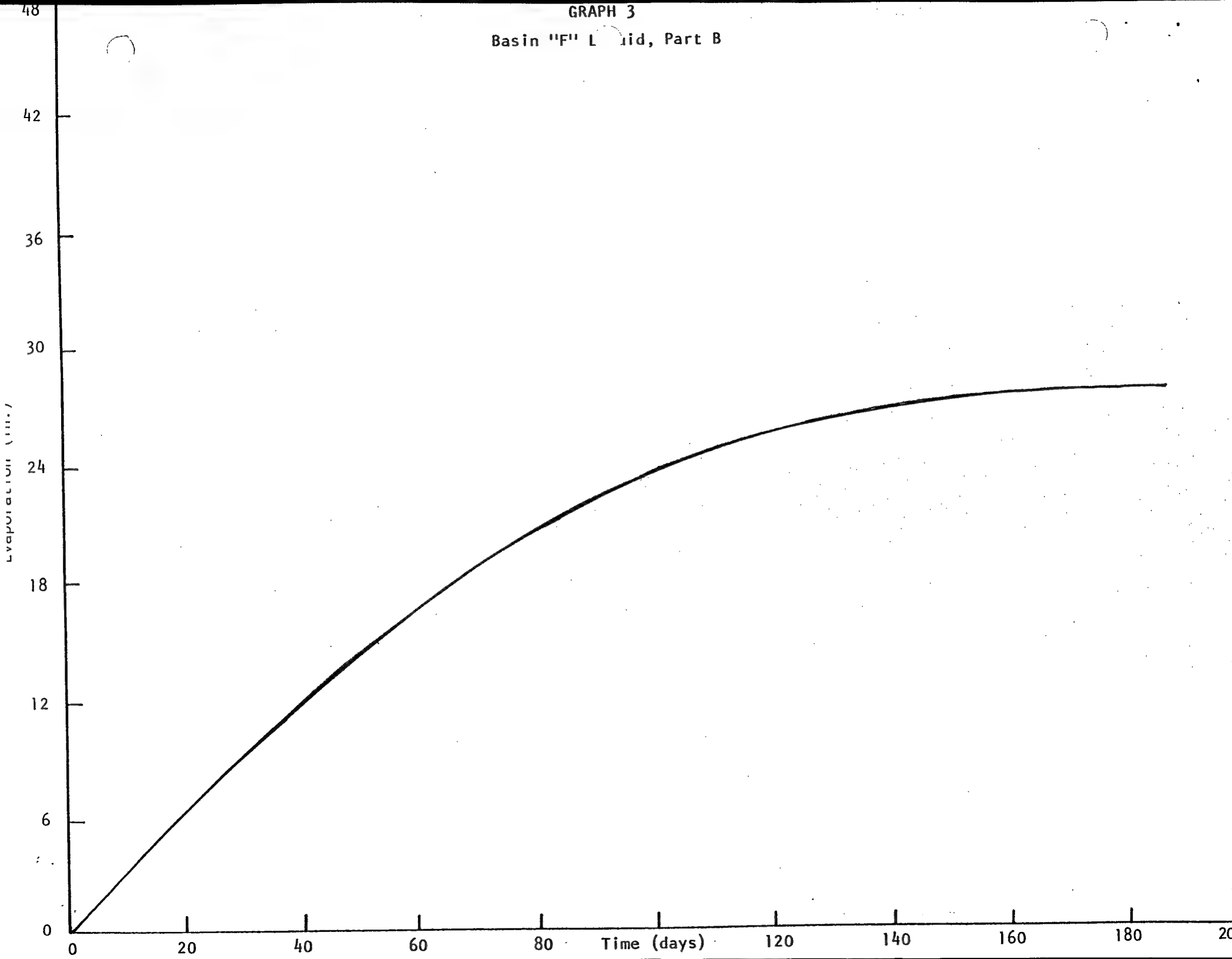
GRAPH 2

Water, Part A



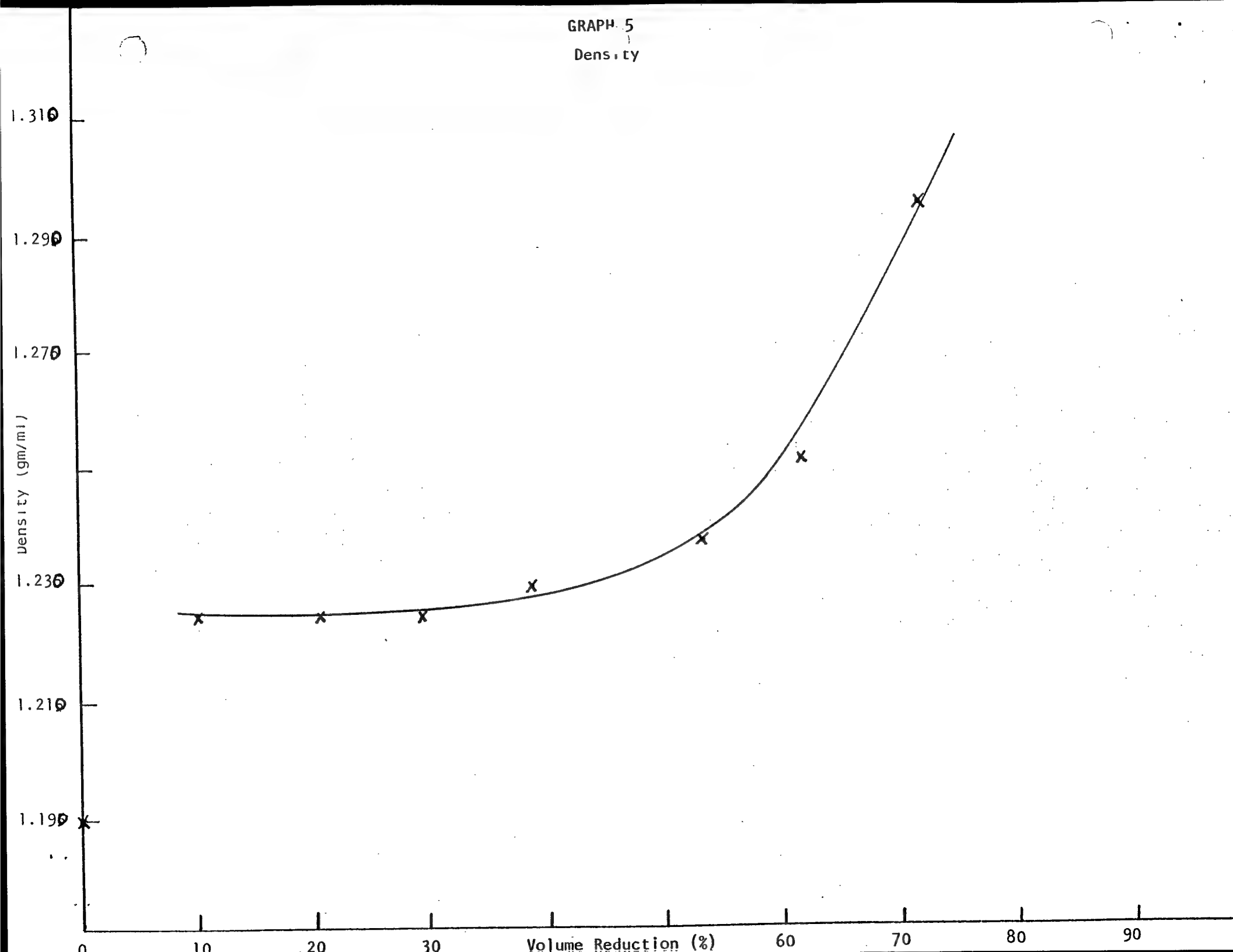
GRAPH 3

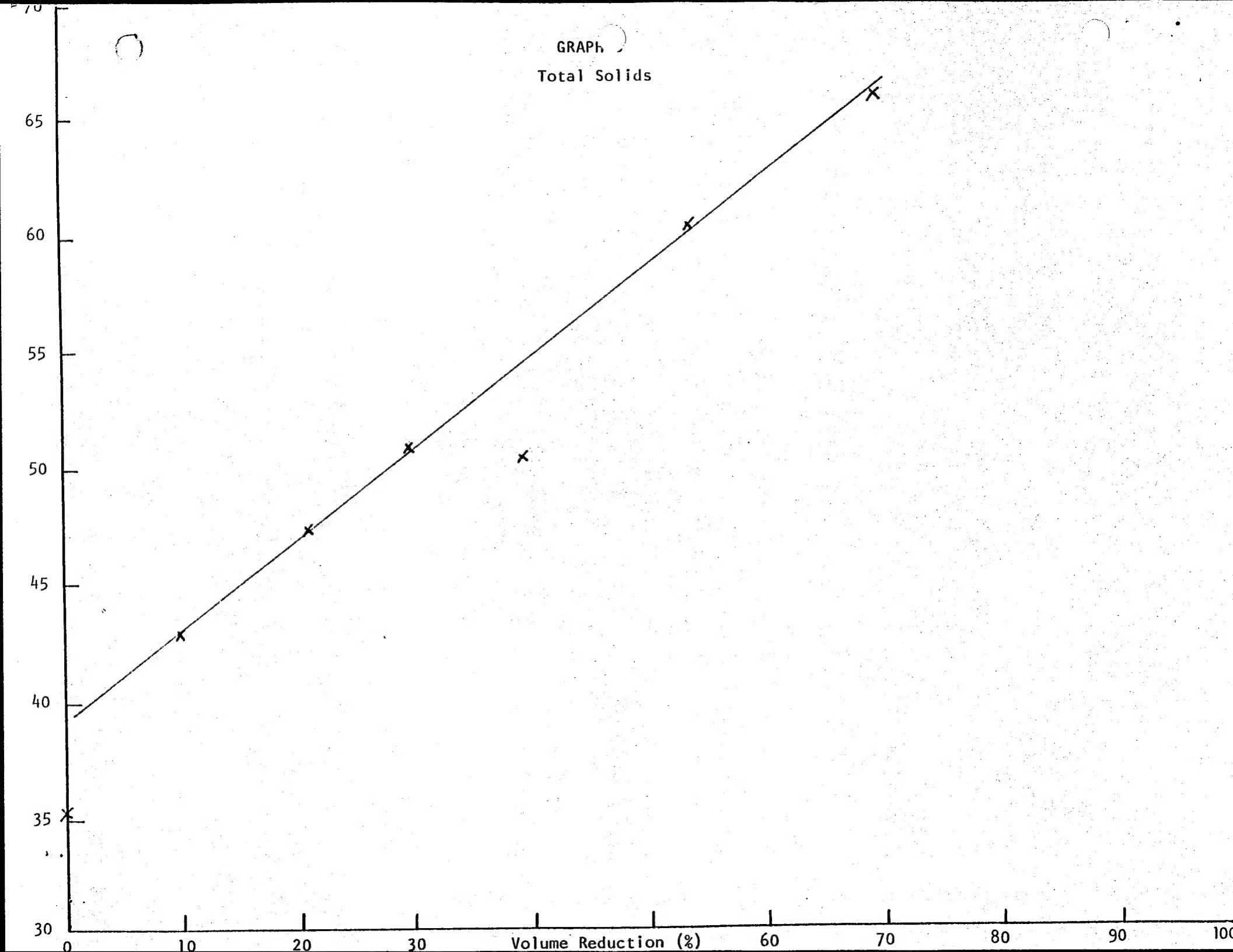
Basin "F" L iid, Part B



GRAPH 5

Density




GRAPh
Total Solids
70
65
60
55
50
45
40
35
30
0
10
20
30
Volume Reduction (%)
60
70
80
90
100

APPENDIX A: CLIMATALOGICAL DATA FOR DENVER, COLORADO

Table A1

Summary of Probability Graphs

	Net Evaporation for Denver, Colorado = Evaporation - Precipitation				
	10% Exceeded	50% Exceeded	90% Exceeded	% of Annual 50% of Exceeded	90% of Exceeded
Month	in./month	in./month	in./month		
January	1.78	1.29	-0.85	2.81	-4.74
February	2.37	1.4	-0.53	3.05	-2.95
March	3.1	1.53	0.23	3.34	1.29
April	3.8	2.5	0.65	5.46	3.63
May	6.16	3.9	0.5	8.52	2.79
June	7.3	5.9	2.7	12.89	15.07
July	8.28	7.0	3.6	15.29	20.09
August	8.14	7.38	5.32	16.12	29.69
September	6.85	5.53	2.7	12.08	15.07
October	5.5	4.5	2.2	9.83	12.27
November	2.97	2.32	0.85	5.06	4.74
December	3.38	2.52	0.55	5.50	3.07
Monthly Mean	4.96	3.81	1.58	8.32	8.82
Standard Deviation	2.33	2.20	1.74		
Annual Evap.	59.63	45.77	17.92	100	100.02

Table A2

Climatalogical Statistics for Denver, Colorado

Month	Mean Monthly Air Temp. F°	Standard Deviation	Variance	Mean Precip.	Standard Deviation	Variance
January	29.34	4.39	18.38	0.540	0.394	0.148
Feburary	33.10	4.45	18.89	0.70	0.450	0.193
March	37.95	4.25	17.19	1.21	0.61	0.359
April	47.48	3.03	8.76	1.86	0.98	0.91
May	57.52	2.61	6.49	2.22	1.86	3.30
June	66.51	2.74	7.177	1.78	1.38	1.81
July	73.01	2.26	4.87	1.80	1.388	1.83
August	71.26	1.91	3.48	1.12	0.825	0.648
September	61.76	3.10	9.18	1.44	1.187	1.34
October	51.60	3.96	14.9	0.96	0.988	0.93
November	38.97	2.49	5.78	0.75	0.436	0.18
December	31.7	3.80	13.76	0.65	0.69	0.45
Annual Average	50.01					